NASA Tropical Rainfall Measuring Mission (TRMM)
TOPIC #1: TRMM: Why Measure Rainfall from Space?

Teacher's Guide to Activities

OVERVIEW: This set of mini-lessons will introduce students to the understanding that water vapor contains latent or "stored" heat which is released when the water vapor condenses into cloud droplets or rain. When this heat is released into the atmosphere it has the potential to affect global weather and climate. Monitoring rainfall from space allows scientists to collect data more thoroughly and consistently in regions within the range of the satellite than would be possible with ground based rain gauges. Since 65% of the world rainfall occurs in the topics, satellite instruments are focused on this region of Earth. With increased data on rainfall and latent heat scientists can more accurately construct computer models to predict problems related to Global Warming. This lesson includes a collection of activities to enable students to appreciate the importance of monitoring rainfall from space and provides an Internet site for students to view NASA remote sensing images from the Tropical Rainfall Measuring Mission (TRMM) satellite.

LEARNING OBJECTIVES:
Students will be able to:
- Measure latent (stored) heat of evaporation
- List the steps in the water cycle to include the transfer of energy
- Debate the issues related to Global Warming
- Analyze NASA remote sensing images from the TRMM satellite

NATIONAL SCIENCE EDUCATION CONTENT STANDARDS: The activities provided in this lesson meet Content Standards A,B,D,E,F and G. A comprehensive list of the Content Standards and relevant subtopics is located on page 5 of the Teacher's Guide.

ACTIVITY TITLES
The following lessons meet Expectations within MSDE CORE Goal #2.

Activity #1 The Issue of Global Warming: How can TRMM help?
(Overview) Expectations: #1,3,8

Activity #2 The Role of Latent Heat in the Water Cycle
(Mini lab) Expectations: #3,5

Activity #3 Latent Heat's Disappearing Act
(Lab activity) Expectation: #3

Activity #4 Interpreting TRMM Satellite Images
(Internet activity) Expectation: #1

VOCABULARY

TRMM – a NASA satellite called Tropical Rainfall Measuring Mission which measures rainfall in the tropical regions of the Earth

Global Warming – the warming of the Earth due primarily to an increase of carbon dioxide gas. The burning of gasoline and coal adds carbon dioxide to the Earth's atmosphere

Latent heat – heat which is "stored" as the increased motion of water molecules as they evaporate and become water vapor. This heat is released when water vapor condenses back to a liquid

ANSWER KEY TO ACTIVITIES

Activity #1: The Issue of Global Warming- How can TRMM Help?

1. Reasons we are concerned about Global Warming:
   - Coastal flooding
   - Changes in rainfall patterns
   - Increased number of hurricanes

   Reasons we do not want to reduce the burning of coal & oil
   - Coal is used to produce electricity
   - Oil powers our automobiles
2. Latent heat
3. Monitoring rainfall from space is more thorough and consistent than rain gauges

Activity #2: The Role of Latent Heat in the Water Cycle

1. Wet bulb
2. The heat was absorbed by the water vapor molecules as latent heat of evaporation
3. Latent heat is "hidden energy" such as the energy stored in water vapor molecules as they vibrate
4. Latent heat is released when water vapor condenses into clouds or precipitation.
5. The scientists monitor the release of latent heat
6. Information about latent heat will help scientist understand how this added heat affects weather and climate

Activity #3: Latent Heat's Disappearing Act

1. Answers will vary. Subtract starting the temperature from the temperature at which the water boiled.
2. The temperature remained constant
3. The heat was "hidden" in the escaping water vapor molecules as latent heat of evaporation
4. Latent heat affect global weather patterns.

Activity #4: Interpreting TRMM's Satellite Images

1. Green
2. January 1998
3. Pacific Ocean
4. Zero millimeters .
5. Pacific Ocean, near the Equator
6 Below the Equator
7. Winter
8. Summer, 2 to 4 mm
9. Africa
10. See the red regions on "TRMM Microwave Imager" map
11. National Science Education Standards

The NASA/TRMM Activities support the following standards:

Contents Standards; Grades 5-8

A. Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

B. Physical Science
- Properties and changes of properties in matter
- Transfer of energy

C. Life Science

D. Earth and Space Science
- Structure of the Earth

E. Science and Technology
- Abilities of technological design
- Understandings about science and technology

F. Science in Personal and Social Perspectives
- Natural Hazards
- Science and technology in society

G. History and Nature of Science
- Science as a human endeavor
- Nature of science

Contents Standards; Grades 9-12

A. Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

B. Physical Science
- Structure and properties of matter
- Interactions of energy and matter

C. Life Science

D. Earth and Space Science
- Structure of the Earth
- Geochemical cycles

E. Science and Technology
- Abilities of technological design
- Understandings about science and technology

F. Science in Personal and Social Perspectives
- Natural and human-induced hazards
- Science and technology in local, national and global challenges

G. History and Nature of Science
- Science as a human endeavor
- Nature of scientific knowledge